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A Survey of the Thickness of the Shoe Sole among Junior High School Students in Greater Jakarta for Shoe Correction in *Seat Height-Popliteal Height* Equation

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Abstract

This paper aimed to present a survey result of the thickness of the shoe sole among junior high school students in Greater Jakarta, Indonesia. A number of 160 samples of the shoe wearing by junior high school students (85 boys and 65 girls) from Grade 7-Grade 9 was measured. The thickness of the sole of the shoe wearing by them were measured. The results were presented in mean and SD for each grade and gender. T-test results showed that no significant differences were found for thickness of the sole of the shoe wearing by boys and girls within the same grade. Anova test results also revealed that no significant differences were found for thickness of the sole of the shoe among boys in Grade 7-9 (F=0.54, p=0.58) and girls (F=1.06, p=0.35). Findings in this study revealed that a 20mm shoe correction, as often used by many researchers, which is added to the popliteal height to dimension the seat height (SH) is appropriate to be used for population under study. The results of this study provided sufficient justification for the use of a 2 cm shoe correction (SC) in addition to popliteal height when determining seat height of the chair.

1. INTRODUCTION

School furniture –seat and table- plays relevant role in maintenance of a good sitting posture (Corlett, 2006; Murphy et al., 2004). For school furniture, the seat height is the starting point to dimension of the chair and desk set (Molenbroek et al., 2003). On the basis of students' anthropometry, it is common for researcher to consider a shoe correction (SC) to be added to popliteal height to dimension the seat height. This is not surprising since most students' activity in the sitting posture were conducted while they were wearing shoe. In addition, the SC is also important to consider since the measurement of popliteal height is conducted with the subject not wearing the shoe.

Seat height is the vertical distance from the floor to the highest point on the front of the seat (Parcells et al., 1999; Panagiotopoulou et al., 2004; Gouvali and Boudolos, 2006; Yanto et al., 2017). To evaluate the ergonomics dimension of the seat height (SH), a few researchers have proposed different equations. Among all, the following equation was mostly used by many researchers: (PH+SC)*Cost 30≤SH≤(PH+SC)*Cost 5 (which PH corresponds to the Popliteal Height, and SC corresponds to the Shoe Clearance). According to Carneiro et al. (2017), it is the only one that consider the biomechanics of the knee and considers that the inferior part of the leg makes an angle of 5-30 degrees in relation to the vertical.

This equation considers the shoe correction (SC) which corresponds to the thickness of the sole of the shoe which is added to the popliteal height (PH). The SC can vary according to the culture, fashion and country with many authors report variations in the order of 20mm, 25mm-45mm (Pheasant, 2003). A few researchers considered a shoe correction (SC) of 20mm to dimension the seat height (SH) (Sanders and McCormick, 1993; Occhipinti et al., 1993; Gouvali and Boudolos, 2006; Dianat et al., 2013; Carneiro et al., 2017; Yanto et al., 2017). In case of office chair, Pheasant (1993) recommended a 2.5cm shoe correction for both sexes to determine seat height. To determine the Hong Kong Standard seat height for school furniture, Evans et al. (1988) used 5th percentile popliteal height with a 45 mm allowance for shoes. Meanwhile, Castellucci et al. (2010) used a 3cm for shoe correction (SC).

To dimension the Seat Height (SH) of a chair, the shoe correction which is added to the popliteal height (PH) is important since almost all students in Indonesia wear shoe while doing their activity in the classroom. However, data of the thickness of the

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sole of the shoe wearing by students in Indonesia is not available. Most studies regarding the evaluation of school furniture used a shoe correction (SC) based on prior use by other authors. Hence, the aim of this study was to obtain the thickness of the shoe sole prevalent used by students and use it as a corresponding shoe correction which can be used in the equation to evaluate seat height of school furniture.

2. METHODOLOGY

2.1 Samples of students' shoe

The thickness of the shoe sole taken is part of students' anthropometric data measurement activities for the purpose of evaluating and designing SNI for junior high school students. Prior to conducting study, a team was sent to get approval from the headmaster. Subsequently, we measured the students' shoe according to convenience method. For the purpose of the study, a sample of 160 junior high school students from 3 schools in Greater Jakarta was taken. The samples consisted of 85 shoes wearing by boys and 65 shoes wearing by girls from Grade 7 to Grade 9.

2.2 The thickness of the shoe sole

The shoe correction was defined as the thickness of the sole of the shoe. The measurements are from the bottom side of the sole of the shoe to the upper side (see illustration in Figure 1).

Figure 1.
Anatomy of the thickness of the shoe sole and the measure in this study

2.3 Procedures

For this study, three university students were recruited for the measurement activity. Prior to conducting measurements, each university student was sent to get approval from the school headmaster. Subsequently, the students were selected from each grade based on convenience basis.

Considering that almost all students have more than one shoe, this study only considered the shoe which was wearing by students during school day at the time of the measurement. For each shoe, we measured twice and the measuring ouput is the average of the two measures. In addition, the measurements were based on the right shoe only.

2.4 Data Analysis

From the raw data, the data were calculated and presented in mean and standard deviation of the thickness of shoe sole from each gender and grade, Normality tests were conducted to check the normality assumption of the data for sole of the shoe wearing by both boys and girls from each grade. T-test was conducted to check whether any difference between the thickness of the sole of the shoe of boys and girls within the same grade. Anova tests were also conducted to check the differences among the thickness of the shoe sole among students from different grade. In addition, one sample t-test (with $H_0: \mu = \mu_0$) was conducted to investigate to the parameter of the thickness of the shoe sole which would appropriate to be chosen as the value of Shoe Correction (SC) for Indonesian population under study.

3. RESULTS

Table 1 shows the mean and standard deviation (SD) of the thickness of the sole of the shoe of the junior high school students from Grade 7-9 (in cm) for both boys and girls. Regarding the data, normality tests were conducted to observe whether the data were normally distributed. The results showed that the data were normally distributed for each grade and gender (with all p-values are greater than 0.01).

T-test results showed that there were no significant differences of the thickness of the shoe sole of the students between boys and girls from Grade 7 (T=-0.59, p=0.56), Grade 8 (T=0.79, p=0.44), Grade 9 (T=1.94, p=0.06). Moreover, anova test showed that there was no significant difference of the thickness of the shoe sole for boys from Grade 7-9 (F=0.54, p=0.58). Similarly, no significant difference was found for girls from Grade 7-9 (F=1.06, p=0.35). Considering the results of t-test and anova, the mean and standard deviation of shoe thickness for all students in this study (n=159) are 2.06 cm and 0.60cm.

Considering that a 2 cm shoe correction was often used by many researchers (Occhipinti et al., 1993; Sanders and McCormick, 1993; Gouvali and Boudolos, 2006; Dianat et al., 2013; Carneiro et al., 2017; Yanto et al., 2017; Yanto, 2018), one sample t-test (with $H_0: \mu = 2.0$) was conducted to investigate whether the finding in this study is relevant with that. Using one sample t-test for the null hypothesis $H_0: \mu = 2.0$ cm, with the mean and SD of all samples are $\bar{x} = 2.06$ and $SD = 0.6$ ($n = 159$), the result showed that there was no evidence to reject H_0 (T=1.25, p=0.21). The result is shown in Table 2 for the null hypothesis $H_0: \mu = 2.0$.

Table 1.
Mean and SD of the thickness of the shoe sole of students from Grade 7-9 (in cm)

Students	Boy		Girl		Total
	Mean	SD	Mean	SD	
Grade 7	2.02	0.61	2.12	0.51	
Grade 8	2.16	0.56	2.01	0.66	
Grade 9	2.22	0.65	1.87	0.55	
Total	2.12	0.62	1.98	0.58	2.06 (±0.60)

Table 2.
Results of t-test for null hypothesis

Shoe correction (μ_0)	Null Hypothesis	Alternative Hypothesis	T-test results
$\mu_0 = 2.0$	$H_0: \mu = 2.0$	$H_1: \mu \neq 2.0$	T=1.25, p=0.21
$\mu_0 = 2.5$	$H_0: \mu = 2.5$	$H_1: \mu < 2.5$	T=-9.20, p=0.00
…	…	…	…
$\mu_0 = 4.5$	$H_0: \mu = 4.5$	$H_1: \mu < 4.5$	T=-51.1, p=0.00

For higher shoe correction (SC), one sample t-tests were also performed for the null hypothesis $H_0: \mu = 2.5$ cm and $H_0: \mu = 4.5$ cm with two alternative hypothesis $H_1: \mu < 2.5$ and $H_1: \mu < 4.5$ consecutively. Using the mean and SD of all samples, $\bar{x} = 2.06$ and $SD = 0.6$ ($n = 159$), the result showed that there was evidence to reject H_0 (T=-9.20, p=0.00) for $H_0: \mu = 2.5$. Similarly, the result was also to reject $H_0: \mu = 4.5$ (T=-51.1, p=0.00) for $\mu_0 = 4.5$. The results of hypothesis testing were summarized in Table 2.

4. DISCUSSION

In this study, the thickness of the shoe sole of junior school students in Greater Jakarta, Indonesia were measured and studied. The thickness of the shoe sole, called Shoe Correction (SC), in addition with popliteal height was usually used to determine the recommended seat height for the school students. Although different equations were used, a shoe correction (SC) was always considered to the popliteal height of students to consider the seat height of the chair. Most researchers recommended a 2cm correction for shoe height regardless different gender and grade of students (Sanders and McCormick, 1993; Occhipinti et al., 1993; Gouvali and Boudolos, 2006; Yanto et al., 2008; Dianat et al., 2013; Carneiro et al., 2017; Yanto et al., 2017; Yanto et al., 2018). Findings in this study confirmed that a 2cm shoe height correction (SC) could be used and generalized in addition to popliteal height of students to determine the seat height (SH) of a chair.

Despite its simplicity, findings in this study can be a basis for strengthening the use of appropriate shoe correction (SC) to be used for a *seat height (SH)~Popliteal height (PH) evaluation*. As consequences, the equation $(\boldsymbol{PH} + \boldsymbol{SC})\ \boldsymbol{Cos}\ \boldsymbol{30^0} \leq \boldsymbol{SH} \leq (\boldsymbol{PH} + \boldsymbol{SC})\ \boldsymbol{Cos}\ \boldsymbol{5^0}$ which used by many researchers could be modified into $(\boldsymbol{PH} + \boldsymbol{2})\ \boldsymbol{Cos}\ \boldsymbol{30^0} \leq \boldsymbol{SH} \leq (\boldsymbol{PH} + \boldsymbol{2})\ \boldsymbol{Cos}\ \boldsymbol{5^0}$ as findings in this study showed that a 2cm no evidence to reject $\boldsymbol{H_0: \mu = 2.0}$ (T=1.25, p=0.21). Again, this study confirmed that a 2 cm shoe correction (SC) which was often used by many researchers (Sanders and McCormick, 1993; Occhipinti et al., 1993; Gouvali and Boudolos, 2006; Yanto et al., 2008; Dianat et al., 2013; Rosyidi et al., 2014; Carneiro et al., 2017; Yanto et al., 2017; Yanto, 2018) is appropriate to be used to evaluate the seat height (SH) of chair as related to the popliteal height of students.

5. CONCLUSION

This paper presents a survey of the thickness of the shoe sole which can be used to determine the appropriate shoe correction (SC) in *Seat height (SH)~Popliteal height (PH) evaluation.* Findings in this study confirmed that a 2cm correction is the most appropriate to be used for shoe height correction (SC) in addition to popliteal height to determine seat height. Since the samples were taken from 3 schools only, while Indonesia consists of large geographical areas, the conclusions in this study are needed to be noted with caution. Therefore, results of this study provided sufficient justification for the use of a 2 cm shoe correction (SC) in addition to popliteal height when determining seat height of the chair. This study is the first study to confirm appropriate shoe correction (SC) based on survey from the shoes of the students.

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